STUDY ON SOIL NUTRIENT MANAGEMENT AND FERTILIZATION MODEL IN NINGXIA COUNTY TERRITORY WITH GIS

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Abstract: By adopting the GIS technology, this thesis tries to collect and recognize the existing pedological map, the soil nutrient graphic document and other related documents data of Ningxia. And with the classification and filtration to the material, the spatial databases and the attribute database can be established to combine the county territory soil nutrient data and the geography graph together to make the uninteresting form data visualized. Based on the soil nutrient database, the mathematical model is established by means of the design of the regression orthogonal combination. And Through the mathematical model optimization, the quantity of nitrophoskas which is employed at the maximum production rate as well as at the lowest can be obtained. With these, the paper proposes a model which can dispose, judge and analyze all the factors related to the fertilization to achieve the concrete formula and the amount of commonly used fat and the special-purpose compound fat. Therefore, the data analysis and the auxiliary decision-making enormously facilitate, and the automatization and the rationalization of all kind of crop's fertilization scheme in Ningxia can be realized.

Keywords: GIS, Soil nutrient; Fertilizer model, Goal output, Fertilizer parameter

1. INTRODUCTION

For lack of the essential soil test facility, it is difficult to implement fertilization by soil test in some undeveloped area in China. Therefore, “the average suitablility recommendation fertilization” arises at this historic background to characterize the technology of soil test and fertilizer recommondation with Chinese characteristic. With the statement of “the digital agriculture” concept, as well as the establishment of national soil and terrain digital database, based on the geographic information system(GIS), there massively appeared many fertilizer systems which have been recommended by experts(Wang et al., 1998). This research with the aid of the GIS spatial data managerial technique, the synthesis uses methods and so on spatial superposition, visualization to carry on the effective management to the Ningxia county territory soil nutrient data(Li et al., 2003; L. et al., 2003). And in this data foundation, in view of the Ningxia characteristic crops, the basis applies fertilizer balanced the theory, applies fertilizer the parameter with the aid of each kind, establishes the regression model, had determined commonly used fat and special-purpose compound fat applies fertilizer the plan; Established interactive, the intellectualized characteristic crops to apply fertilizer the software to instruct the farmer pointed qualitative, the quota to apply fertilizer, raised the fertilizer use factor, realized crops' high production, high quality, has achieved the low consumption, the highly effective goal.

2. MATERIALS AND METHODS

2.1 Soil nutrient data management

Take Visual c# and SuperMap Objects5 as the software development platforms to establish the Ningxia soil nutrient data management system which includes 1:50000 pedological map, the soil nutrient graphic document, the general detailed soil survey data and the attribute data. This system can be applied from the soil spatial data to the soil nutrient data management, the inquiry and the data search. Soil attribute database will display every soil nutrient target and its spatial databases in electronic map to demonstrate the variation rule of these nutrient targets.

2.1.1 Database establishment

According to different data format, the data may be partitioned as the spatial data and the attribute data. In this system the spatial data namely refers to the description space position and the corresponding relational data, adopt the Ningxia Hui Autonomous Region 1:50000 topographic diagram to carry on the digitization, the spatial databases of the entire district can be obtained. Every soil space attribute (area, perimeter, name, code number, respective county territory and so on) can be put in the working space database table. The attribute data mainly refers to the soil attribute database, according to the system designing plan and the procedure need, to program the soil attribute database, establish the structure of the database, its field and the main line directs. Based on the general detailed soil survey investigation, the chemical examination analysis result and the N, P, K as well as the trace element correlation data from the Agriculture department, with the input of these soil attribute database, the soil attribute database's will relate to each soil nutrient target space data through the key field, to fully demonstrate these nutrient target in the electronic map in the spatial distributed situation.

2.1.2 Data inquiry and retrieval

The spatial data inquiry can be realized by SuperMap Objects 5 through options and soil land parcel, soil distribution as well as regionalism, the window browser which corresponds with the graphic data may be turned on to realize each kind of soil spatial data and the attribute data visualization graphic mode demonstration and according to the actual operation request to carry on the enlargement, the reduction, the migration and the return to original state to the electronic map. The inquiry and the search function of attribute data are completed by Visual c#, by clicking an essential factor of sampling point graph to demonstrate its attribute, this can also be got by using the sector selection tool, simultaneously chooses in the region which assigns many sampling points to extract and demonstrate after its statistical analysis the overall attribute, Its schematic diagram is shown in Fig.1

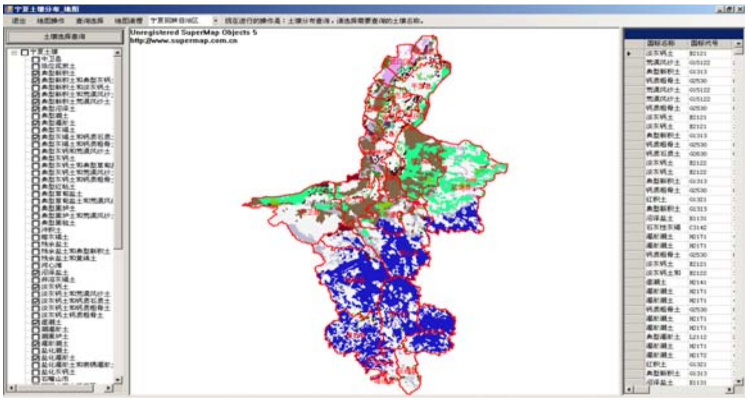

Fig.1: The distributing map of soil in Ningxia

2.1.3 Data maintenance and dynamic updating

In the crops growth process, influenced by many kinds of extraneous factors and the production actual need, the database momentarily must face the maintenance and the renewal question. The long-term agricultural cultivation will change the soil nutrient target, therefore the soil attribute database should renew the value, even increase or the reduced corresponding field suitably.

2.2 Fertilization model establishment

The soil quantity fertilizer's determination receives aspect and so on crops type and production level, soil type and for fat ability, fertilizer type variety and use factor, climate and agricultural technology syntheses affects(Hou et al., 2003). According to the establishment soil nutrient database, selects the Ningxia Hui Autonomous Region five characteristic crops: The wine-making grape, the Chinese matrimony-vine, the silkworm raising, the ma-huang, the licorice have established the regression model, this model mainly realizes applies fertilizer the formula automation, the rationalization, the core question is the soil nutrient, the fertilizer use factor as well as the crops needs the nutrient the parameter estimation, is as follows according to three Yuan two return orthogonal unitized design regression equation:

$$Y = a+bx_1+Cx_2+dx_3+ex_1x_2+fx_2x_3+g\,x_1x_3+h\,x_1^2+i\,x_2^2+j\,x_3^2 \qquad (1)$$

And, x_1 is the nitrogen element demand (kg/hm^2), x_2 is the phosphorus element demand (kg/hm^2), x_3 is the potassium element demand (kg/hm^2), Y is the goal output (kg/hm^2), a, b, c, d, e, f, g, h, i, j are the fertilizer field test regression equation coefficients, they change along with the different crops soil texture.

2.2.1 Fertilization quantity at maximum production rate

Disregard the product price, the nitrogenous fertilizer price, the phosphate fertilizer price and the potassium fertilizer price, just evaluate the regression equation (1) about x_1, x_2, the x_3 first-order partial derivative and make them to zero, then the biggest fertilizer quantity under all levels of output foundation will be figure out and apply the fertilizer quantity to the formula, the maximum production rate is possible to obtain.

$$x_{N1} = \frac{-4bij - def - cfg + 2idg + 2cej + bf^2}{8hij + 2efg - 2ig^2 - 2je^2 - 2hf^2} \qquad (2)$$

$$x_{P1} = \frac{-4chj - bfg - \deg + cg^2 + 2bej + 2dfh}{8hij + 2efg - 2ig^2 - 2je^2 - 2hf^2} \qquad (3)$$

$$x_{K1} = \frac{-4ihd - ceg - ebf + 2big + e^2 d + 2hfc}{8hij + 2efg - 2ig^2 - 2je^2 - 2hf^2} \quad (4)$$

x_{N1}, x_{P1}, x_{K1} is the quantity of azote, phosphor and kalium at the maximum production rate, b, c, d, e, f, g, h, i, j is a coefficient.

2.2.2 Fertilization quantity for best economic efficiency output

When crops, nitrogenous fertilizer, phosphate fertilizer and potassium fertilizer unit price are known, revises the original regression model to be as follows：

$$L = Yp - x_1 p_N - x_2 p_P - x_3 p_K \quad (5)$$

L is the real return, Y is the goal output (kg/hm^2), x_1 is the nitrogen, the phosphorus and the potassium element demand (kg/hm^2) respectively, p, p_N, p_P, p_K are the crops unit price, the nitrogenous fertilizer unit price, the phosphate fertilizer unit price and the potassium fertilizer unit price respectively. Substitutes (5) in the formula (1) type：

$$L = (a + bx_1 + Cx_2 + dx_3 + ex_1x_2 + fx_2x_3 + g\, x_1x_3 + h\, x_1^2 + i\, x_2^2 + j\, x_3^2)p - x_1 p_N - x_2 p_P - x_3 p_K \quad (6)$$

according to the principle that the best quantity fertilizer should be equal to the marginal cost, the equation best quantity fertilizer as well as the best output may be obtained. Also namely evaluate (6) about x_1, x_2, the x_3 first-order partial derivative, and make it to zero.

$$x_{N2} = \frac{4ij(\frac{p_N}{p} - b) + gf(\frac{p_P}{p} - C) + ef(\frac{p_K}{p} - d) + f^2(b - \frac{p_N}{p}) + 2ej(c - \frac{p_P}{p}) + 2ig(d - \frac{p_K}{p})}{8hij + 2efg - 2ig^2 - 2je^2 - 2hf^2} \quad (7)$$

$$x_{P2} = \frac{fg(\frac{p_N}{p} - b) + 4hj(\frac{p_P}{p} - C) + eg(\frac{p_K}{p} - d) + 2ej(b - \frac{p_N}{p}) + g^2(c - \frac{p_P}{p}) + 2fh(d - \frac{p_K}{p})}{8hij + 2efg - 2ig^2 - 2je^2 - 2hf^2} \quad (8)$$

$$x_{K2} = \frac{ef(\frac{p_N}{p} - b) + eg(\frac{p_P}{p} - C) + 4hi(\frac{p_K}{p} - d) + 2ig(b - \frac{p_N}{p}) + 2hf(c - \frac{p_P}{p}) + e^2(d - \frac{p_K}{p})}{8hij + 2efg - 2ig^2 - 2je^2 - 2hf^2} \quad (9)$$

x_{N2}, x_{P2}, x_{K2} is the quantity of azote, phosphor and kaliumtime at the best output.

In the system, the crops goal output which is input must be smaller than the greatest output, otherwise the system will prompt the user to correct automatically. Moreover, the quantity fertilizer which calculates based on the above formula, if smaller than zero, it means there is no need apply fertilizer.

3. RESULT AND DISCUSSION

3.1 Formula Schemes for commonly used fat and special-purpose compound fat

3.1.1 Trace element demand computation

With the above established fertilizer applying model, the annual amount of crops nitrogen phosphorus potassium needed is possible to be obtained, to fully consider the influence of soil texture to the parameter of fertilizer applying, the annual demand for the trace element should be calculated too, which involves the zinc, the manganese, the copper, the iron and the boron, the calculation step as follows (take zinc as example):

(1) Selects soil type and the crop pattern, gain the soil parameter and the crops parameter from the corresponding database table.

(2) Calculates the annual demand of trace element (kg/hm^2)

$$m=(Y*k/1000-0.15*n*q)/r \quad (10)$$

And m is the trace element zinc demand (kg/hm^2), Y is the goal output (kg/hm^2), k is 1000 kilograms output needs the nutrient (kg/hm^2), n is the soil nutrient content (kg/hm^2), q is the soil nutrient supply rate (kg/hm^2), r is the fertilizer use factor.

3.1.2 The common chemical fertilizer nutrient provides situation

Table 1, Table 2 shows the the proportion of N、P、K and microelementin familiar fertilize separately

Table 1 the proportion of NPK in familiar fertilizer

	$(NH_4)H_2PO_4$	$(NH_4)_2HPO_4$	$CO(NH_2)_2$	NH_4HCO_3	$(NH_4)_2SO_4$	$Ca(H_2PO_4)_2 \cdot H_2O$	$CaCO_3$	K_2SO_4	KCl
N	12%	18%	46 %	17 %	20 %				
P	52%	46%				12%	43%		
K								50%	55%

Table 2 the proportion of microelement in familiar fertilizer

	$ZnSO_4$	$MnSO_4$	$CuSO_4$	$FeSO_4$	$Na_2B_4O_7.10H_2O$	H_3BO_3
Zn	40.5%					
Mn		24.6%				
Cu			25.9%			
Fe				19%		
B					11%	17%

Because the fertilizer is numerous, according to the actual situation during the fertilizer apply different choice can be made, rests on the fertilizer which is provided, the nitrogen element not only contains in ammonium and two ammonium, moreover also contains in the urea, the ammonium carbonate and the ammonium sulfate; At the same time, the phosphorus element not only contains in ammonium and two ammonium, moreover also contains in the Pu calcium and the heavy calcium. How to solve the problem of the origin of nitrogen and phosphorus is rather difficult, in the article ammonium or two ammonium is supposed to act according to the actual situation in overall fertilizer proportion then the problem can be solved by evaluating the rate of the nutrient proportion contains in each hectare as well as the chemical fertilizer.

3.1.3 Realization of fertilization formula scheme

1）**Commonly used fat formula**

Based on the fertilizer employment's actual situation, may make the following choice: Ammonium and two ammonium two elect one, the urea, the ammonium carbonate, the ammonium sulfate three choose one, Pu calcium and the heavy calcium two elects one, solves the nitrogen, the phosphorus origin question by this, the potassium sulfate, the potassium chloride two elects one, solution potassium origin question. In trace element's origin question, the zinc, the manganese, the copper, the iron easy to solve, the borax and the boric acid two elect one, solution boron origin question.

2）**Special-purpose compound fat formula**

What is different from the commonly used fat formula: The urea, the ammonium carbonate, the ammonium sulfate three elect two, the Pu calcium and the heavy calcium all elect, but must consider the following parameter in the formula: Nitrogen, phosphorus, potassium proportion, trace element proportion, compound fat always available nutrient content, trace element content as well as additive level.

3.2 Application process

The model of the soil applies fertilizer in the application process, fully considers the soil texture to the soil parameter influence. The core question is the soil fertilizer applying ability, the fertilizer profitability and the estimation on nutrient needed by crops. Its step is:

(1) Take the electronic map as the basis, according to geography plan gain soil type and basic soil nutrient data, choice planter crops.

(2) Based on key field value system constructs the SQL inquiry sentence, found the corresponding record of the soil and the crops from the database (Gu et al., 2005).

(3) system automatically read the related parameter which the model needs from the database record, other parameters which inputs on the man-machine interaction graphical interface carries on the model computation together with the user, obtains the nitrogen, the phosphorus, the potassium as well as the trace element demand.

(4) Choose the fertilizer formula plan, obtains the common chemical fertilizer concrete employment quantity, the computed result dynamic demonstration on the graphical interface.

4. CONCLUSION

Based on the GIS Ningxia county territory soil nutrient data management as well as the establishment of fertilization formula scheme, the thesis fully considers the different crops' need, the fat requirement rule and the coordinated relations between different soil, overcame the general method that has used qualitative primarily applies fertilizer. To a great extent, it reduced certain blindness, managed for the Ningxia farmland soil nutrient and applies fertilizer the decision-making to provide effective technological means. Through the GIS farmland soil nutrient management, may facilitate the inquiry application, according to the farmland soil nutrient's condition and the difference, the possible arrangement planting plan and formulates and applies pointed strong technical and the cultivation management measure; The union soil nutrient, the crop pattern, the application applies fertilizer the model to carry on the crops fertilizer recommendation formula, will be advantageous in obtains reasonable output and the benefit, and is advantageous to the protection soil and the agriculture ecological environment. In the research, carries on with many test point cooperations applies fertilizer the experiment, and has carried on the big area promoted application. The practice proved that this software has the high precision and the promoted value in the application.

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